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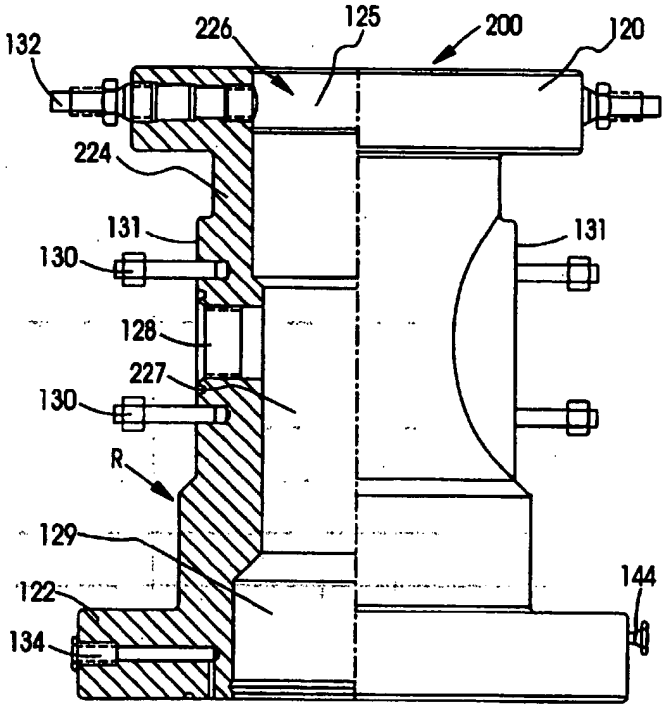
(54) **RACCORD DOUBLE-BRIDE POUR TETE DE TIGE**
(54) **TUBING HEAD SPOOL**



(57) A tubing head spool for use with a BOP protector in fracturing or stimulation treatments is described. The tubing head spool includes a reinforced area of its sidewall that is adjacent a bottom flange of the spool and surrounds a supports an annular seal which provides a sealing engagement between the end of the BOP protector and a secondary seal in a bottom of the spool. The reinforced area contains radial pressure transferred through the annular seal during well stimulation treatments. The reinforced area has a pressure rating greater than the pressure rating of the remainder of the tubing head spool so that the modified tubing head spool is adapted for use with the BOP protector for high pressure well stimulation treatments. The advantage is an economic tubing head spool that enables safe high pressure well treatments at pressures up to the pressure rating of the reinforced area of the tubing head spool.

ABSTRACT OF THE DISCLOSURE

A tubing head spool for use with a BOP protector in fracturing or stimulation treatments is described. The tubing head spool includes a reinforced area of its sidewall that is adjacent a bottom flange of the spool and surrounds a supports an annular seal which provides a sealing engagement between the end of the BOP protector and a secondary seal in a bottom of the spool. The reinforced area contains radial pressure transferred through the annular seal during well stimulation treatments. The reinforced area has a pressure rating greater than the pressure rating of the remainder of the tubing head spool so that the modified tubing head spool is adapted for use with the BOP protector for high pressure well stimulation treatments. The advantage is an economic tubing head spool that enables safe high pressure well treatments at pressures up to the pressure rating of the reinforced area of the tubing head spool.

TUBING HEAD SPOOL

TECHNICAL FIELD

The present invention relates to equipment for servicing oil and gas wells and, in particular, to a tubing head spool which is adapted to be used in a high pressure stimulation treatment of an oil or gas well using a blowout preventer protector.

BACKGROUND OF THE INVENTION

The servicing of oil or gas wells to stimulate production requires the pumping of fluids under high pressure. The fluids are generally corrosive and/or abrasive because they are frequently laden with corrosive acids and/or abrasive proppants such as sharp sand. Some hydrocarbon producing formations require stimulation and extreme pressures to break up the formation and improve the flow of hydrocarbons to the well. If such wells are equipped with a wellhead, it is advantageous to use specialized tools called wellhead isolation tools which are inserted through the wellhead and related equipment to isolate pressure sensitive components from the extreme pressure required to stimulate those wells. Wellhead isolation tools are taught, for example, in United States

Patent Nos. 4,867,243, 5,332,044 and 5,372,202 which issued to the Applicant respectively on September 19, 1989, July 26, 1994 and December 13, 1994.

In other wells, stimulation to improve production can be accomplished at more moderate pressure which may be safely contained by blowout preventers (BOPs) attached to the well casing. In those instances, some operators remove the wellhead equipment and pump stimulation fluids directly through a valve attached to the BOPs. This procedure is adopted to minimize expense and to permit full access to the well casing with tools such as logging tools, perforation guns and the like during the well servicing operation.

When pumping abrasive fluids into a well, the pump rate must be kept high to place the proppants without "screening out", in which a blockage occurs and/or the equipment including the high pressure lines are blocked with abrasive injected under high pressure. When the pump rate is high or large quantities of proppants are pumped, the BOPs may be damaged by the cutting action of the proppant. If high rates of abrasive proppants are pumped through a BOP, the blind ram of the BOP or the valve gates can be "washed out" so that the BOP becomes inoperable.

If stimulation treatments are to exceed pressures at which the wellhead equipment is rated, a wellhead isolation tool, a casing saver or a casing packer have to date been the only tools available for isolating the wellhead from extreme pressure and abrasion. Although it is not uncommon for certain wells to be stimulated at pressures which do not exceed the pressure rating of the wellhead equipment (about 5000 psi), it is quite common that wells require extreme pressure treatments (usually in the range of 10,000 to 15,000 psi) for production stimulation. If the stimulation pressure is higher than 5,000 psi, the BOPs must be protected from the pressure because they are not constructed to contain extreme pressures.

A protector for protecting a blowout preventer from exposure to fluid pressure as well as abrasive and/or corrosive fluids during well fracturing and/or stimulation treatment to stimulate production comprises a spool which is mounted above the blowout preventer. A mandrel can be stroked down from the spool through the blowout preventer until an annular seal engages a top end of the casing to isolate the blowout preventer and protect it from exposure to fluid pressure as well as abrasive and/or corrosive fluids during well stimulation

treatments, and stroked out of the blowout preventer after the well has been stimulated. The BOP protector is described in United States Patent Application Serial No. 08/783,860 filed by the Applicant on January 16, 1997 and allowed on April 27, 1998, which is incorporated herein by reference.

Although the BOP protector described above represents a significant advance in the art, its use is limited to the pressure rating of the tubing head spool in which it is packed off. This is due to the annular seal which is radially supported by the tubing head spool. The annular seal between the mandrel and a secondary seal in the tubing head spool is an elastic seal which contains the high pressure corrosive fluids but it is not adapted to contain the radial pressure to which it is exposed. The annular seal therefore exerts the same radial pressure against the supporting surface of the inner periphery of the tubing head spool as the fluid pressure it contains. Consequently, well stimulation treatments cannot be safely conducted at pressures above the pressure rating of the tubing head spool, typically 5,000 psi. Tubing head spools having higher pressure ratings are commercially available but they are expensive and are superfluous unless a well

requires high pressure stimulation. It is therefore desirable to provide a tubing head spool which may be made commercially available at a reasonable price but adapted to be used in a stimulation process using higher pressure fluids.

SUMMARY OF THE INVENTION

An object of the invention is to provide a tubing spool which is inexpensive to manufacture but may be used with a BOP protector to effect high pressure well stimulation treatments.

Another object of the invention is to provide an improved tubing head spool generally having a low pressure rating which is adapted to be used with a BOP protector for high pressure fracturing and stimulation treatments.

It is yet a further object of the invention to provide a method of stimulating a well to improve production using a BOP protector and a tubing head spool having a low general pressure rating but adapted to be used with the BOP protector for high pressure stimulation treatments.

In accordance with one aspect of the invention, there is provided a tubing head spool which comprises a

top flange adapted for mounting wellhead components thereto, a bottom flange adapted to mount to a surface flange of a hydrocarbon well and to connect with a casing of the well and a sidewall that extends between the top and bottom flanges to define a profile adapted for accepting a tubing hanger; the top flange, the bottom flange and a substantial portion of the sidewall having a first pressure rating and a reinforced area of the sidewall adjacent the bottom flange having a second pressure rating that is greater than the first pressure rating, the reinforced area of the sidewall being adapted to surround and support a seal of a blowout preventer (BOP) protector when the BOP protector is packed off against a top of the casing.

The reinforced area of the sidewall extends above a portion of the profile that receives the secondary seal. The secondary seal preferably includes a bit guide at a top thereof and the reinforced area of the sidewall extends above a portion of the profile at a top of the bit guide.

The tubing head spool is isolated from exposure to high pressure corrosive fluids when the mandrel of the BOP protector is stroked down through the tubing head spool and the annular seal sealingly engages the

secondary seal. Therefore, the pressurized fluids used for well stimulation treatments are contained in the mandrel by the secondary seal. Nonetheless, the annular seal of the BOP protector is elastic. Since it is supported by the sidewall of the tubing head, it exerts radial pressure thereon which is equal to a fluid pressure of the well stimulation fluids. The reinforced area of the sidewall is thicker than the rest of the sidewall, however, and has a higher pressure rating so that the tubing head spool may be used to effect high pressure stimulation treatments up to the second pressure rating when a BOP protector is sealed against the secondary seal.

In accordance with another aspect of the invention, there is provided a method of using a tubing head spool with a mandrel in fracturing or stimulating a hydrocarbon well, the tubing head spool having a top flange adapted for mounting wellhead components thereto, a bottom flange which is mounted to a surface flange of the well and connected to a casing of the well by a secondary seal, and a sidewall extending between the top and bottom flanges, the tubing head spool having a first pressure rating except for a reinforced area of the sidewall adjacent the bottom flange, the reinforced area

surrounding and extending above the secondary seal and having a second pressure rating that is greater than the first pressure rating, the method comprising inserting the mandrel into the tubing head spool from a top thereof, the mandrel being connected to a high pressure fluid supply for fracturing or stimulating the hydrocarbon well, a bottom end of the mandrel including an annular seal means for high pressure sealing engagement with a top of the secondary seal; sealing the annular seal means against the secondary seal so that the annular seal means is surrounded and supported by the reinforced area of the sidewall having the second pressure rating; fracturing or stimulating the well by controllably introducing high pressure fluids from the supply source though the mandrel and into the casing; and removing the mandrel from the tubing head spool after the fracturing or stimulation process is complete and the fluid pressure has been bled off.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be explained in more detail by way of example only and with reference to the following drawings, wherein:

FIG. 1 is a cross-sectional view of a prior art tubing head spool connected with a blowout preventer and a BOP protector in service for well stimulation treatment;

FIG. 2 is a side view of a prior art tubing head spool partially in cross-section to show the inside thereof when it is in service as illustrated in FIG. 1;

FIG. 3 is a cross-sectional view of a secondary seal used with the tubing head spool illustrated in FIG. 2;

FIG. 4 is a side view of one preferred embodiment of the invention partially in cross-section to show the inside thereof; and

FIG. 5 is a cross-sectional view of the embodiment illustrated in FIG. 4 to show the inside thereof when it is in service in the same way as illustrated in FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a prior art tubing head spool connected with a BOP protector in service for a well stimulation treatment. The BOP protector 10 is mounted above a BOP 40 and a high pressure valve spool 60 is mounted to the top of the BOP protector 10. An adapter

spool 70 may be mounted above the high pressure valve spool 60. The BOP 40 is connected through a tubing head spool 100 to a top end of a casing spool 80 in a manner well known in the art. The BOP protector 10 comprises a protector spool 12 having a top end 14, a bottom end 16, and spaced apart inner and outer sidewalls 18 and 20 that extend between the top end 14 and the bottom end 16. The bottom end 16 is mounted above the BOP 40 and the top end 14 is adapted for the attachment of another spool or a union, or a high pressure valve spool 60. The BOP protector 10 is provided with a mandrel 22 which has a top end 24 and a bottom end 26, the top end 24 being received in an annular cavity between the inner and outer sidewalls 18 and 20 and forcibly reciprocatible within the cavity by pressurized fluids which can be introduced or drained from either top port 25 or bottom port 27. The bottom end 26 of the mandrel 22 includes a mandrel extension 28 and a mandrel pack-off assembly 30 which supports an annular seal 32 for high pressure sealing engagement with a secondary seal 102 at the bottom of the tubing head spool 100.

FIG. 2 is a detailed view of the tubing head spool 100 illustrated in FIG. 1. The tubing head spool 100 comprises a top flange 120 adapted for mounting

wellhead components thereto, such as a blowout preventer 40 as shown in FIG. 1; a bottom flange 122 adapted to be mounted to a surface flange of a casing spool 80 of a hydrocarbon well and to connect with a casing 82 of the well; a sidewall 124 that extends between the top and bottom flanges 120, 122 to define a central passage 126 adapted for accepting a tubing hanger (not shown). Two studded side outlets 128 extend transversely through the sidewall, respectively and a plurality of studs 130 are provided around each side outlet 128 on a plain surface 131 for connection of a flanged outlet thereto (not shown). The tubing head spool is provided with lock screw assemblies 132 at the top flange 120 in sufficient quantity to support the tubing hanger. Each of the lock screw assemblies 132 includes manually energized elastomer seals for safe and effective pressure isolation, which is well known in the art. The central passage 126 includes a tubing hanger segment 125, a middle segment 125 with which the two side outlets 128 communicate, and a lower segment 129. The lower segment 129 receives a secondary seal 102 to isolate annulus pressure. This secondary seal 102 controls and isolates pressure. Secondary seals are known to be efficient and reliable in various applications. The bottom flange 122

contains a pressure test port 134, which permits positive testing of annular seals.

FIG. 3 shows a commonly used secondary seal preferably used in a tubing head spool in accordance with the invention. The secondary seal provides an integral bit guide 136. Bit guide 136 protects the seal bore and helps direct inner tubular strings. Inside diameters of the bit guide 136 maintain a minimum restricted bore based on the lightest standard casing weight. The secondary seal 106 comprises an interchangeable sleeve 139 and incorporates a mechanically energized elastomer ring 142 to maintain annular pressure isolation. The sleeve 139 in the secondary seal has channels 146 that communicate with a sealant port 144 in the bottom flange 122 of a tubing head spool and the annular groove in which the elastomer ring 142 is received. This type of seal provides dependable service up to 10,000 psi.

A preferred embodiment of the invention is illustrated in FIG. 4. The tubing head spool 200 of the preferred embodiment is similar in structure to the tubing head spool 100 shown in FIG. 2. The tubing head spool 200 comprises a top flange 120 adapted for mounting wellhead components thereto; a bottom flange 122 adapted to mount to the surface flange of the casing spool 80 and

to connect with the casing 82 of the well; and a sidewall 224 that extends between the top and bottom flanges 120, 122 to define a central passage 226 for accepting a tubing hanger. The sidewall 224 preferably includes two side outlets 128 transversely extending through the sidewall 224 respectively. A plurality of studs 130 are provided around each of the side outlets 128 on a plain surface 131 for connection of flanged outlets (not shown). The bottom flange 122 contains a test port 134 for positive testing of annular seals and a sealant port 144 which communicates with the channels of secondary seal 106 shown in FIG. 3 for injection of plastic packing.

The central passage 226 includes a tubing hanger segment 125 which has a diameter slighter greater than a diameter of a middle segment 227. The side outlets 128 communicate with the middle segment 227. A lower segment 129 of the central passage 226 has a diameter greater than the diameter of the middle segment 227 to receive the secondary seal 106. Lock screw assemblies 132 are also provided in the top flange 120 in sufficient quantity to lock down a tubing hanger in the tubing hanger segment 125. The tubing head spool 200 includes a reinforced area R of the sidewall which

extends upwardly from the bottom flange 122 about 4 to 5 inches (10 to 13 cm) from a top of the secondary seal 106. The reinforced area R has a pressure rating greater than the pressure rating of the remainder of the tubing head spool 200. In this embodiment, the reinforced area R of the sidewall 224 has a pressure rating of 10,000 psi and the remainder of the tubing head spool 200 has a pressure rating of 5,000 psi. Therefore, a fluid pressure of up to 10,000 psi that is transferred by a thermoplastic or synthetic rubber annular seal 32 of a BOP protector during a well stimulation treatment to the sidewall 224 is safely contained by the reinforced area R of the sidewall 224. It will be understood that the pressure rating of the reinforced area R is a matter of design choice and it may be more or less than 10,000 psi, as required.

A method of using the tubing head spool 200 with a BOP protector 10 in fracturing or stimulating a hydrocarbon well will now be described. The tubing head spool 200 and a blowout preventer 40 are normally installed as a part of the original wellhead equipment. To begin the fracturing or stimulating treatment, the blowout preventer 40 is closed and any wellhead equipment above it is removed. The BOP protector 10 is mounted to

the blowout preventer 40 and a high pressure valve is mounted above the BOP protector and is tightly closed. The blowout preventer 40 is fully opened and the mandrel 22 with the mandrel extension 28 of the BOP protector 10 is fully extended through the blowout preventer 40 and inserted into the tubing header spool 200 until the annular seal 32 is sealed against the secondary seal 106 so that the annular seal 32 is surrounded and supported by the reinforced area R of the sidewall which has the higher pressure rating of 10,000 psi, for example. A high pressure fluid supply is connected through a high pressure line (not shown) and high pressure fluids are controllably introduced from the supply through the mandrel 22 and mandrel extension 20 of the BOP protector 10 to the casing 82 to perform the fracturing or stimulation treatment at fluid pressures up to the higher pressure rating. After fracturing or stimulation treatment is complete, the mandrel 22 and the mandrel extension 28 are removed from the tubing header spool 200 and further retracted out of the blowout preventer 40. The blowout preventer 40 is closed and the high pressure line is removed after the fluid pressure in the high pressure line is bled-off. The BOP protector 10 and the high pressure valve are also removed and the wellhead

equipment is replaced to permit hydrocarbon production to resume.

Changes and modifications to the embodiments of the invention described above will no doubt become apparent to those skilled in the art, the scope of the invention is therefore intended to be limited solely by the scope of the appended claims.

I CLAIM:

1. A tubing head spool comprising:

a top flange adapted for mounting wellhead components thereto;

a bottom flange adapted to mount to a surface flange of a hydrocarbon well and to connect with a casing of the well; and

a sidewall that extends between the top and bottom flanges to define a profile adapted for accepting a tubing hanger;

the top flange, the bottom flange and a substantial portion of the sidewall having a first pressure rating, and a reinforced area of the sidewall adjacent the bottom flange having a second pressure rating that is greater than the first pressure rating, the reinforced area of the sidewall being adapted to surround and support a seal of a blowout preventer (BOP) protector when the BOP protector is packed off against a top of the casing.

2. A tubing head spool as claimed in claim 1 wherein the first pressure rating is 5,000 psi and the second pressure rating is 10,000 psi.

3. A tubing head spool as claimed in claim 1 wherein the BOP protector is packed-off against a secondary seal in the bottom flange, the secondary seal including a bit guide at a top thereof and the reinforced area of the sidewall is located in an area surrounding and extending above the bit guide.

4. A tubing head spool as claimed in claim 1 wherein the sidewall includes at least one side outlet in the portion of the sidewall having the first pressure rating.

5. A tubing head spool as claimed in claim 4 wherein the sidewall between the bottom flange and the side outlet is elongated to accommodate the reinforced area having the second pressure rating.

6. A tubing head spool as claimed in claim 5 wherein the reinforced area of the sidewall having the second pressure rating extends upwardly about 4 to 5 inches (10 to 12.7 cm) from a top of the secondary seal.

7. A tubing head spool comprising:

a top flange adapted for mounting wellhead components thereto;

a bottom flange adapted to mount to a surface flange of a hydrocarbon well, and to connect with a casing of the well; and

a sidewall that extends between the top and bottom flanges to define a profile adapted to accept a tubing hanger, a portion of the profile at the bottom flange being adapted to receive a secondary seal to seal the connection of the bottom flange with the casing of the well, the sidewall including two side outlets extending radially therethrough;

the top flange, the bottom flange and a substantial portion of the sidewall having a first pressure rating and a reinforced area of the sidewall adjacent the bottom flange and below the two side outlets having a second pressure rating that is greater than the first pressure rating, the reinforced area of the sidewall being adapted to surround and support a seal of a blowout preventer (BOP) protector when the BOP protector is packed off against the secondary seal to permit high pressure fluids to be pumped into the casing through the BOP protector at fluid pressures up to the second pressure rating.

8. A tubing head spool as claimed in claim 7 wherein the first pressure rating is about 5,000 psi.

9. A tubing head spool as claimed in claim 7 wherein the second pressure rating is about 10,000 psi.

10. A method of using a tubing head spool with a mandrel in fracturing or stimulating a hydrocarbon well, the tubing head spool having a top flange adapted for mounting wellhead components thereto, a bottom flange which is mounted to a surface flange of the well and connected to a casing of the well by a secondary seal, and a sidewall extending between the top and bottom flanges, the tubing head spool having a first pressure rating except for a reinforced area of the sidewall adjacent the bottom flange, that reinforced area surrounding and extending above the secondary seal and having a second pressure rating that is greater than the first pressure rating, the method comprising:

a) inserting a mandrel into the tubing head spool from a top thereof, the mandrel being connected to a high pressure fluid supply for fracturing or stimulating the hydrocarbon well, a bottom end of the

mandrel including an annular seal means for high pressure sealing engagement with a top of the secondary seal;

b) sealing the annular seal means against the secondary seal so that the annular seal means is surrounded and supported by the reinforced area of the sidewall having the second pressure rating;

c) fracturing or stimulating the well by controllably introducing high pressure fluids from the supply source though the mandrel and into the casing; and

d) removing the mandrel from the tubing head spool after the fracturing or stimulation process is complete and the fluid pressure has been bled-off.

11. A method as claimed in claim 10 wherein the pressure of the fluids introduced for fracturing or stimulating the well is raised up to the second pressure rating.

12. A method as claimed in claim 10 wherein the mandrel is a mandrel of a blowout preventer (BOP) protector and the method further includes the steps of:

mounting the BOP protector to a blowout preventer located above the tubing head spool;

closing the at least one high pressure valve;

fully opening the blowout preventer; and

extending the mandrel of the BOP protector through the blowout preventer prior to step a); and

retracting the mandrel out of the blowout preventer;

closing the blowout preventer;

bleeding-off fluid pressure in the high pressure line;

removing the high pressure line; and

removing the BOP protector and the at least one high pressure valve.

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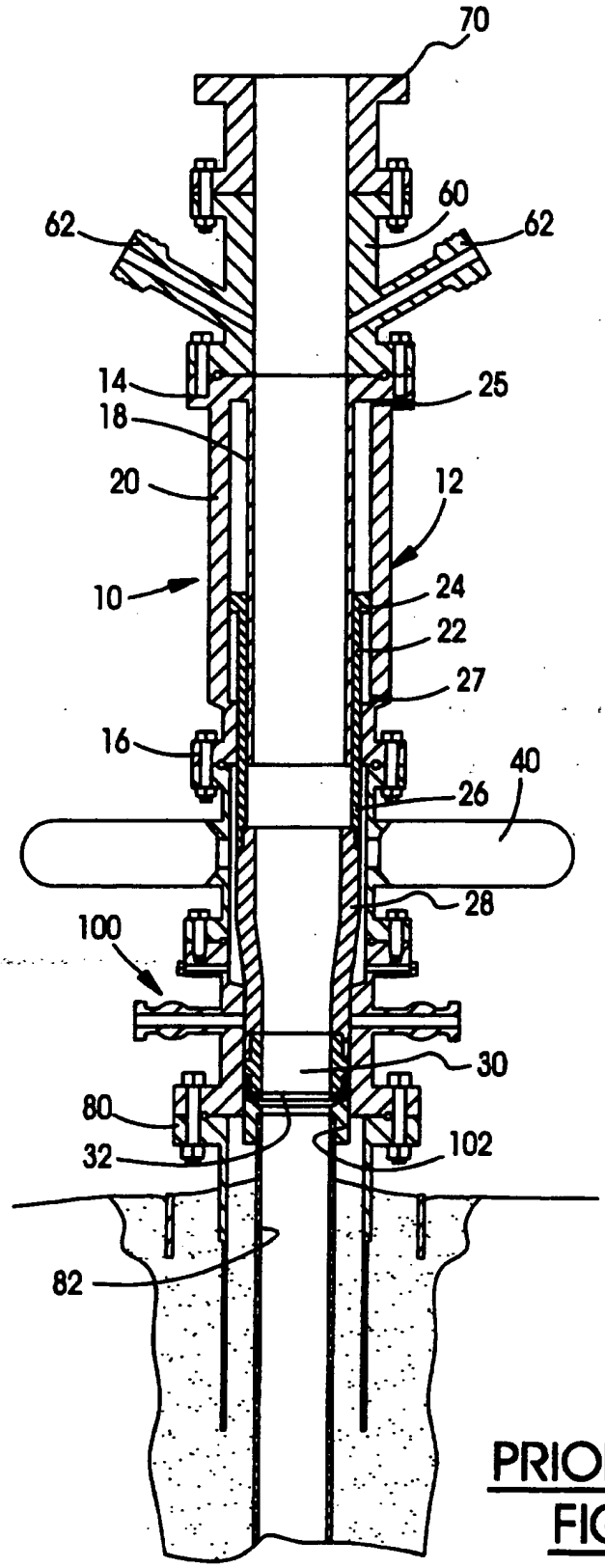
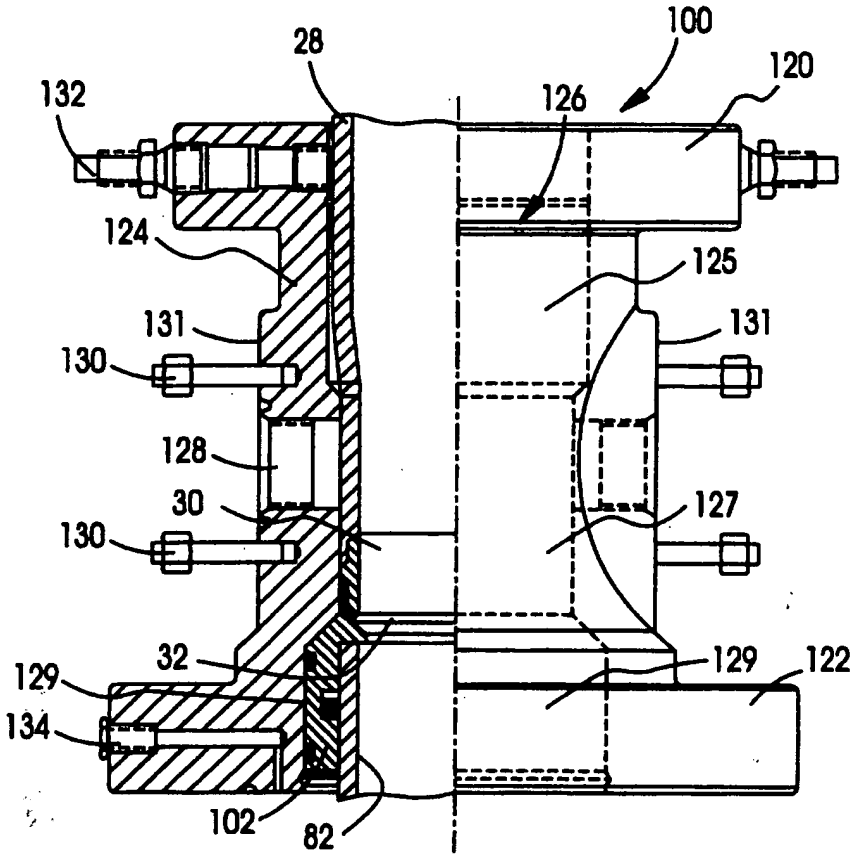
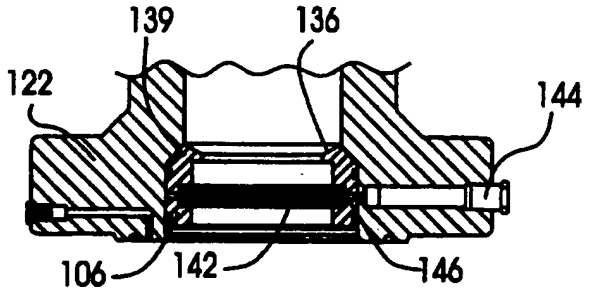


PRIOR ART
FIG. 1



PRIOR ART
FIG. 2



PRIOR ART
FIG. 3

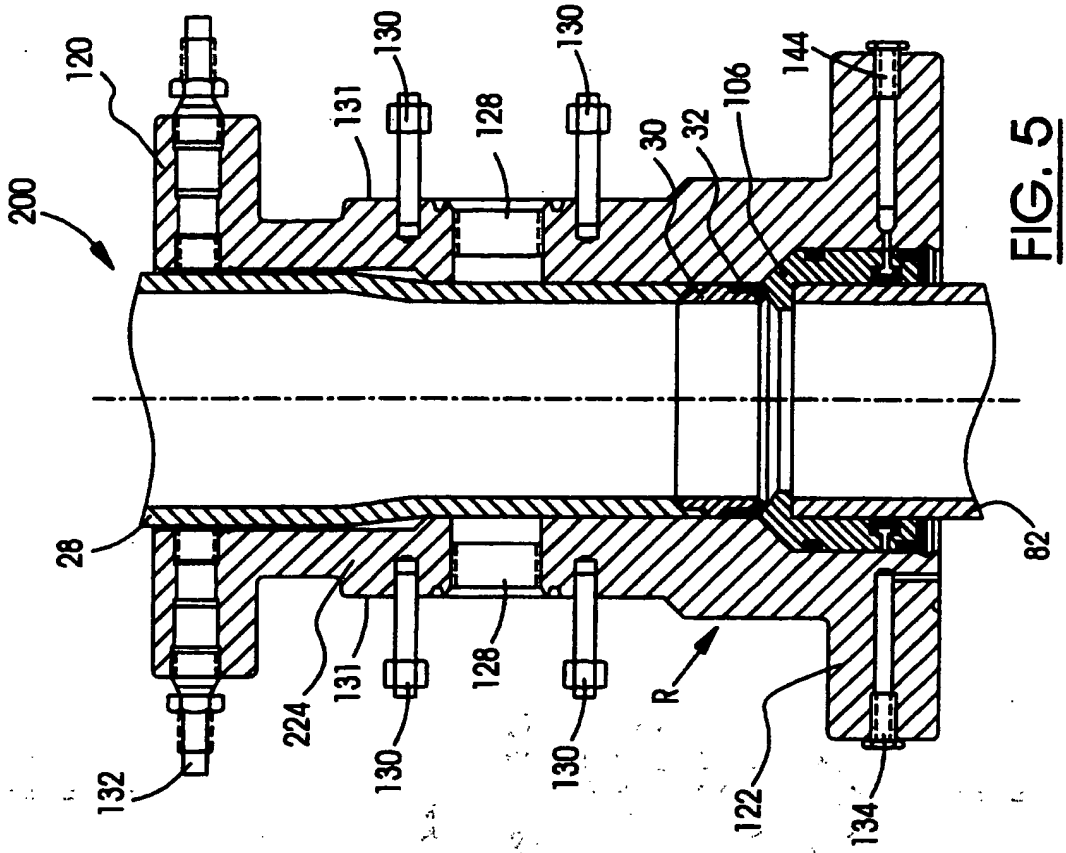

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FIG. 5

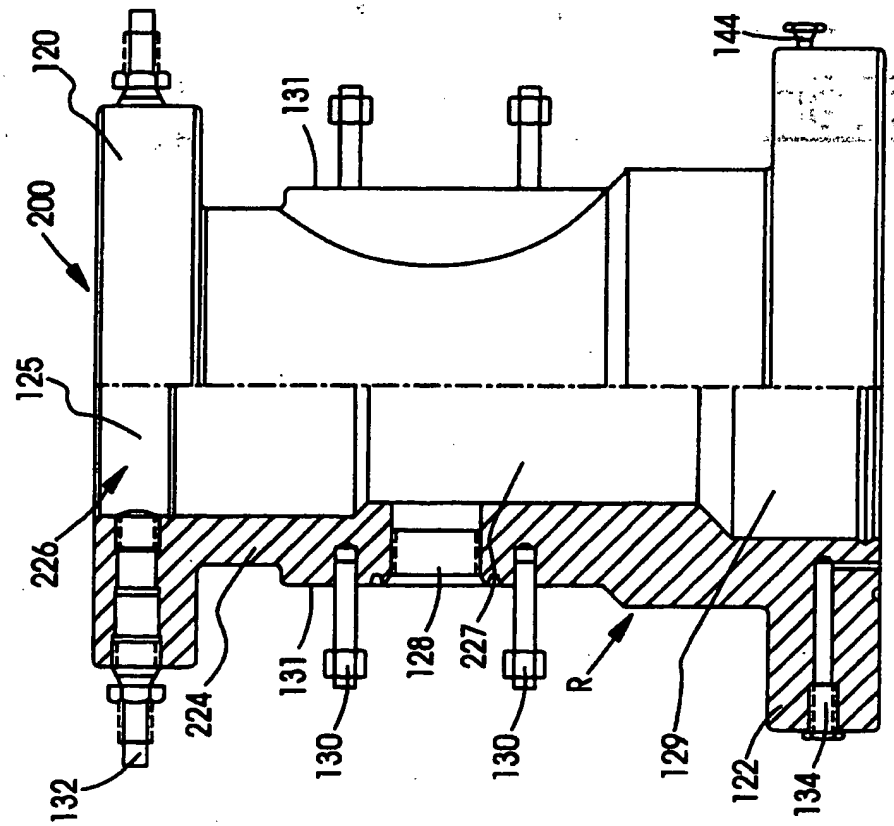
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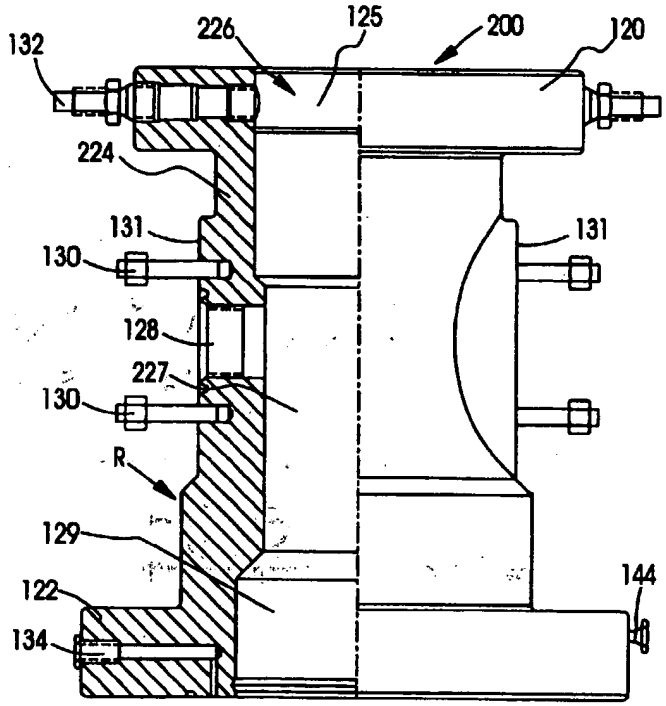
FIG. 4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